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COLORIMETRIC STUDIES OF SOIL COLOR-MATCHING BY FEATHERS OF HOUSE SPARROWS FROM THE CENTRAL UNITED STATES

By Richard F. Johnston

Phenomena associated with qualitative adaptive responses by animals to their environments have interested natural science since at least Classical time, but it has not been until the last 150 years that disciplined or fruitful generalization has proved possible (Gloger, 1833; Darwin, 1859; Mayr, 1942; Williams, 1965). Today it is considered almost tautological to mention organism and adaptation in the same breath, and, when instances of probable color matching between birds and their background environments are found, we cannot say that expectation has been violated. But, probable instances of local adaptive coloration in North American House Sparrows, *Passer domesticus*, are currently of more than casual interest because the extent to which these introduced birds reflect local environmental pressures has not been studied. Accordingly, to learn something about such local variation, samples of sparrows were taken, chiefly in autumn, 1964, from 12 localities in a 1,000-mile transect from montane Colorado through Kansas and Missouri to Illinois (Figure 1). These samples showed pervasive local differentiation in linear dimensions and in color to exist in both males and females; the extent to which differences in color of breasts of females match differences in soil color is reported here.

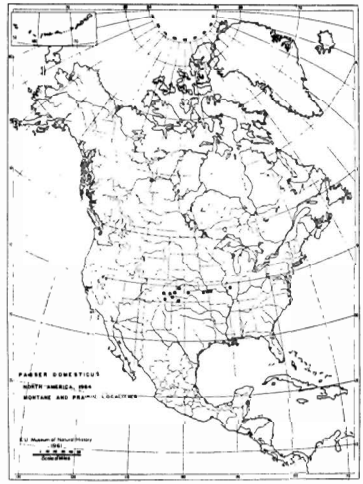


Fig. 1.—Map of North America, showing localities sampled in 1964 (black dots); from east to west they represent Roodhouse, Illinois; Kansas City, Missouri; Kansas City, Lawrence, Hays, St. Francis, and Elkhart, Kansas; and Kit Carson, Pueblo, Colorado Springs, Alamosa, and Gunnison, Colorado.

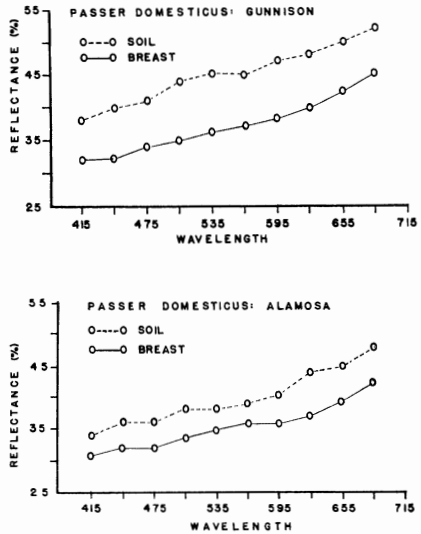
Around 800 birds were taken within a four-week period. Specimens were netted, dispatched, weighed, tagged, placed in plastic sacks, frozen, and only later prepared as conventional study skins. To hasten thawing and to remove foreign matter from feathers, specimens were placed in white gasoline. After they were removed from the gasoline, it was covered and set aside until sediments had formed; the supernatant was then decanted and sediments were dried and placed in small shell vials.

Both soil samples (15 per locality) and specimens (5 per locality) were assessed colorimetrically on a Bausch and Lomb Spectronic 20 colorimeter with reflectance bulb, as has been described earlier (Selander, Johnston, and Hamilton, 1964; Johnston, 1966). Monochromatic light reflected from a standard block of magnesium carbonate was compared with that reflected from soils and feathers, with these being expressed as percentages of the reflection from magnesium carbonate.

Results

Spectral reflectance curves for female breast feathers and soils washed from feathers of both sexes are shown in figures 2 and 3 for the two montane localities in Colorado. Specimens from Alamosa and Gunnison are the palest of specimens from the 12 localities, and the soils washed from their feathers are also the palest in all the samples. The general trend in variation in breast color is clinal, with the eastern, prairie samples being darker than montane samples; this gradual color shift is closely paralleled by soil color. In each instance soils are paler than feathers. It is important to note that the reflectance curves for feathers and soils at any one locality run essentially parallel to one another. Such parallelism indicates that, although the soils are paler than the feathers, the pigments involved have more qualities in common than in distinction.

The relationships can be stated as follows: *hue* (or dominant wavelength) and *chroma* (or saturation) of the feathers and soils are, at each locality, closely similar;



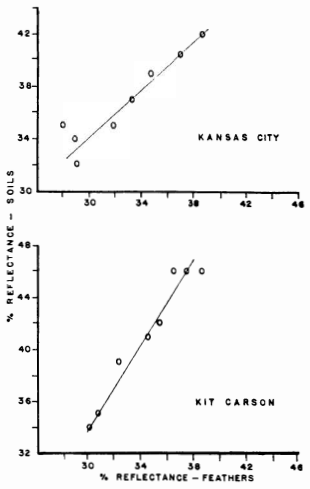


Fig. 2.—Spectral reflectance curves for female breast feathers and soil samples from House Sparrows taken at Gunnison, Colorado; wavelength scale in millimicrons.

Fig. 3.—Spectral reflectance curves for female breast feathers and soil samples from House Sparrows taken at Alamosa, Colorado; wavelength scale in millimicrons.

Fig. 4.—Reflectance readings of breast feathers of House Sparrows plotted against reflectances of soil samples, at eight wavelengths, for Kit Carson, Colorado, and Kansas City, Kansas; see text.

the pallor of the soils relative to the feathers is owing to differences in color *value* (or brightness). To sum it up, the feathers in each instance have slightly more pigment than is necessary to match the "color" of the soils when dry. We may note in passing that consistency in hue and chroma and variation in value (in amount of pigment) is probably a common way of effecting geographic variation in melanin pigmentation; in this way a pigment can be biochemically the same from place to place, but the amount laid down at time of feather formation can be varied locally. This would seem to be true for the several species studied by Dyck (1966:71), for House Sparrows on a continental level (Johnston and Selander, 1964), for Purple Martins *Progne subis* (Johnston, 1966) and for the Crested Lark *Galerida cristata* (Lubnow and Niethammer, 1963), to cite examples from studies using spectrophotometric methods.

Perhaps a more direct way of seeing the relationship between soil colors and feather colors is to compare the reflectance data using bivariate scatter diagrams. Two such comparisons are here presented (Fig. 4), for Kit Carson, Colorado (a high plains locality) and for Kansas City, Kansas (an industrial, urban locality). On the whole the points plot so as to suggest a linear relationship between soil and feather colors; the lines are fitted by eye.

Discussion

It is exceedingly difficult to establish a cause and effect relationship on the basis of descriptive or non-experimental data. In the present instance we may make only a reasonably persuasive argument that the variation in color of House Sparrows is a function of selection against background color variation (or, that we have here an instance of adaptive coloration). It is true that other aspects of the feather coats of both males and females vary in color much as do the female breast feathers—in samples for which pale breasts are characteristic, pale flanks and backs also occur in both sexes, and vice versa. It is likewise true that the plumages represented by the 12 samples in this transect are historically derived from individuals that almost certainly had phenotypes different from birds today in any of the 12. In our study area sparrows were first present in 1872, after an introduction in Topeka, Kansas, of birds from New York (Barrows, 1889); other colonies were formed from the one at Topeka, and the westward advance of sparrows from the east also reached Illinois about 1872. Sparrows, possibly in part descendants of the inoculation at Topeka, had arrived in Boulder, Colorado, by 1898, and at a later time reached the montane localities in the state. Today's coloristic diversity is thus to be derived from stocks originally much more restricted. If we assume for the present that the differentiation is genetically grounded, there are two intriguing questions that may be put.

First, to what extent is the material washed from the birds' feathers a good sample of the soils in places where the birds live? Such material is certainly part of the soil and thus of the color environment of the birds. They regularly oil their feathers and dustbathe, and the finer soil particles adhere to feather surfaces. No doubt most such particles are small, and most such are clays. These are important parts of the color environment of sparrows—recall that clays can remain in fluid suspension for long periods of time, in contrast to sands and loams, and that water and moist soils may be colored by colloidal and finely divided clays. Beyond this, it is not possible to say just how closely the soil samples match the prevailing background color.

The second question coming from an assumption that the color differentiation of the sparrows is genetically grounded concerns the fact that the match is not exact. Since our thesis is that the color matching is a result of natural selection, how nearly alike may we expect the soil and feathers to be? Probably they should not exactly match, at least in autumn when the birds have fresh feather, for the following three reasons:

(1) Feathers of sparrows, in common with those of many species, are faded by continual exposure to the sun, and therefore are darker when new.

(2) Soils become darker when wet.

(3) Feathers are almost always discolored by the soils.

Points 1 and 2 suggest that, in order to get the best long-term or mean color match, new feathers should be darker than background soils and old feathers equal to or

paler than background soils and that wet soils tend to approach the darker color of the feathers when new. In any event, new feathers truly are darker than their associated dry soils. Finally, since the soils usually discolor the feathers, in precisely the direction feathers might be taken by selection were they phenotypically available, we would expect feathers never to exactly match soils. The closer feather color is to soil color the more effectively can soils modify feathers toward prevailing ground color.

A third question stemming from the assumption that color matching is genetic is altogether less intriguing: can the selective agency be anything other than predation by sight-oriented hunters? There is no likely candidate to stand in place of the predators. We may note parenthetically that the range of predators probably important to House Sparrows in mid-continental North America is reasonably broad, as it is in most places: there are two bird hawks (*Accipiter striatus* and *A. cooperii*), two small falcons (*Falco sparverius* and *F. columbarius*), and various owls (chiefly *Tyto alba*); domestic cats; Norway rats (locally, chiefly in Kansas City); squirrels (*Sciurus* spp.); and man. Some of the predators in this list (the owls and the rat) hunt under low illumination and perhaps cryptic plumage is of no value to sparrows being hunted at dusk and at night. Of the remainder, bird hawks are known to take enormous numbers of sparrows under some conditions (Tinbergen, 1946), providing the major source of mortality at some times (up to 80 per cent of total sparrow deaths in Holland, by *Accipiter nisus*; Tinbergen, *op. cit.*). It is doubtful that hunting pressure reaches such dimensions anywhere in the study area, but it is well to keep such figures in mind. The aggregate of predator pressures may well be large in any one place, because they are additive.

It thus seems altogether likely that the following conclusions are warranted: the matching of feather color of North American House Sparrows to dominant aspects of soil color in several midcontinental localities seems to be an instance of adaptive response by sparrows to environmental pressures; the fact that the color match is not perfect, that feathers are darker than their associated soils, is consistent with the hypothesis that the color match is adaptive; and, the differential representation of phenotypes is mediated by selection by visual predators. The color differentiates have had maxima of from about 90 generations, in eastern Kansas, to about 60 generations, in montane Colorado, in which to evolve their unique characters.

Summary

Pigments of breast feathers of female specimens of House Sparrows taken in fall are colorimetrically nearly identical to soil pigments from places in which the birds dustbathe. Specifically, hue and chroma are the same for the two sets of pigments; they differ only in value (brightness). The probable causes of such color matching include natural selection by visual predators. Local differentiation in feather color thus may occur rapidly (within 90 generations), very probably reflecting environmental pressures.

Acknowledgments

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OBSERVATIONS ON EAGLES IN KANSAS

BY H. A. STEPHENS

In winter months from January 1957, to March 1962, I travelled approximately 75,000 miles in most of Kansas. Bald and Golden eagles seen along roads during this period were recorded, and total numbers recorded are listed in Table 1. This roadside count does not include the numbers of eagles seen at roosting or feeding sites.

These data definitely indicate that the greatest numbers of eagles are present in December. The increase in the proportion of Bald to Golden eagles seen through the years may reflect an increased accuracy of identification rather than a change of the actual proportion. Most eagles were seen west of a line extending north along the eastern edge of Clark County, and in general within 25 miles of the Arkansas River.

TABLE 1

NUMBERS OF EAGLES COUNTED ALONG KANSAS ROADS, 1957–1962.

		1957	1958	1959	1960	1961	1962	Total
Jan.	Golden	1	2	15	3	7	10	38
	Bald	1	2	20	10	5	9	47
Feb.	Golden		8	1	10	10	3	32
	Bald		6		4	3	5	18
Mar.	Golden			2				2
	Bald						3	3
Nov.	Golden				3			3
	Bald					4		4
Dec.	Golden	28	10	28	18	4		88
	Bald	16	5	23	15	13		72
Total	Golden	29	20	46	34	21	13	163
	Bald	17	13	43	29	25	17	144
								307

Eagle Roosts

The majority of eagles seen in the following roosts were identified as Bald Eagles, but because of their distance from the observer or position, no attempt was made to distinguish between immature Bald and adult Golden eagles. The number given is the greatest number counted at one time over a period of 10 years:

Stafford Co.: Quivira National Wildlife Refuge, 45 eagles.
Finney Co.: 14 miles northeast of Garden City, 17 eagles.
1 mile west of Pierceville, 75 eagles.
Gove Co.: 14 miles south of Gove, 6 eagles.
Hodgeman Co.: 8 miles north, 5 miles west of Jetmore, 18 eagles.
15 miles west, 7 miles north of Jetmore, 6 eagles.
Clark Co.: Clark County State Lake, 22 eagles.
Neosho Co.: Neosho County Waterfowl Management Area, 17 eagles.
Linn Co.: Marias des Cygnes Waterfowl Management Area, 15 eagles.
Kearny Co.: 3 miles east of Lakin, south of the Arkansas River, 16 eagles.
Phillips Co.: Kirwin National Wildlife Refuge, probable roost.
Arkansas River: probably several roosts between Rice and Hamilton counties.

The following localities are additional places where eagles are commonly seen:

Hamilton Co.: south of the Arkansas River, west of Syracuse.
Kearny Co.: Lake McKinney, near Lakin.
Seward Co.: along the Cimarron River northeast if Liberal and south of U S 54.
Meade Co.: Meade County State Lake.
Hodgeman Co.: along Pawnee Creek.
Ford Co.: along the Arkansas River east of Dodge City.
Barton Co.: Cheyenne Bottoms (Marvin Schwilling has seen 80 eagles in one day).
Rice Co.: along the Arkansas River west of Sterling.

Eagle Nests

Johnston (*A Directory to the Birds of Kansas* (Misc. Publ. No. 41, Univ. Kansas Mus. Nat. Hist.), 1956:17) reports one nesting of the Golden Eagle in Kansas (Comanche County, prior to 1891), and there appear to be no other records of nest-building for either species of eagle in the state. I have seen several nests built by eagles in Kansas, but have never found any eggs. These nests have been identified by their immense size (three to four times as large as hawk or heron nests) and by the presence of eagles. In Hodgeman County, I climbed into one eagle nest, presumed to be that of a Bald Eagle, and when I stretched out across the nest people beneath the tree could not see me.

Since I have never seen an eagle place a stick in a nest, the species to which a nest belongs has been taken to be the same as the species of eagle in or near the nest. Presumed Golden Eagle nests found were thick vertically whereas presumed Bald Eagle nests were somewhat flattened. I have only once observed a Bald Eagle with nesting material and I have never seen a Golden Eagle with sticks. These nests are often built in Great Blue Heron colonies, and for some unknown reason the heron colonies used by eagles have later been abandoned by the herons, or have greatly decreased in size. The only exception to this is a Kearny County heron colony, and here the eagle nest was one quarter mile away and the eagles were never observed within the nesting area of the herons. Usually the eagles do not arrive until the herons have left the colonies and leave before the herons return. The following accounts give the known histories of eagle nests that I have observed:

Kearny Co.: 3 miles east of Lakin, south of the Arkansas River (near a heron colony).
1/15/1959: Bald Eagle seen carrying a 6-foot stick in its feet. I drove about ¾ mile away and watched for 1½ hours while the eagle flew from tree to tree holding the stick, but the bird did not place it.
12/18/1959: a poor nest about ¼ mile north of a heron colony (3 Bald Eagles near).
12/3/1960: nest in poor condition (8 Bald Eagles near).
11/28/1961: nest gone (16 Bald Eagles in area).

Gove Co.: 14 miles south, 1 mile east of Gove (in heron colony).
12/14/1957: nest first seen this date, not there in December, 1956 (2 unidentified eagles present).
1/16/1959: nest in good condition (no eagles present).
12/17/1959: nest in poor condition (1 Golden Eagle, ¼ mile south).
December, 1960: nest gone.

Lane Co.: 14 miles south, 7 miles east of Dighton (in heron colony).
2/22/1958: nest first seen, built on heron nest (2 Bald Eagles near).
5/27/1958: herons nesting in eagle's nest.
12/30/1958: tree with nest blown down; no sign of nest.
12/18/1959: new nest built on another heron nest.

12/3/1960: nest in good condition; new nest (smaller) in same tree.
11/29/1961: nest in good condition; small nest gone (2 Bald Eagles near).
11/23/1962: nest in fair condition (no eagles present).

Lane Co.: 14 miles south, 9 miles east of Dighton.
12/3/1960: nest first seen (no eagles present).
11/29/1961: nest in good condition (2 Golden Eagles on rim of nest).
11/23/1962: nest in fair condition (no eagles near).

Ness Co.: 11 miles south, 2 west of Beeler.
2/22/1958: nest first seen (no eagles present).
12/30/1958: nest in good condition (2 Bald Eagles near).
12/18/1959: nest in poor condition (1 Golden Eagle near).
12/3/1960: nest gone.

Hodgeman Co.: 11 miles south, 3 miles east of Jetmore.
December, 1956: nest first seen, in good condition.
3/10/1957: nest lined with dry grass, more than 6 feet across and 3 feet deep, with a shallow depression (no eagles present).
12/14/1957: nest in good condition (1 Bald Eagle near).
12/30/1958: nest in good condition (2 Bald Eagles near).
December, 1959: nest in fair condition (no eagles present).
December, 1960: nest gone.

Hodgeman Co.: 15 miles west, 7 miles north of Jetmore (in heron colony).
12/14/1957: nest first seen, partly built on old heron nest (2 Bald Eagles in adjacent trees); another nest, well built, 1 mile south.
5/27/1958: Great Horned Owl nesting in south nest.
12/30/1958: north nest complete, in good condition (2 Bald Eagles near); south nest in fair condition.
12/18/1959: north nest in good condition (3 Bald Eagles near); south nest rebuilt.
12/2/1960: north nest in good condition; south nest in poor condition (no eagles present).
12/29/1961: north nest in good condition; south nest gone.
11/23/1962: north nest gone.

Hodgeman Co.: 8 miles north, 2 miles west of Jetmore (in heron colony).
12/9/1956: nest first seen, north of heron colony.
12/14/1957: nest larger (several Bald and Golden eagles near); new nest in south part of colony (4 Bald Eagles near).
12/30/1958: north nest in good condition; south nest in good condition (1 Bald Eagle and 4 unidentified eagles near).
12/18/1959: north nest falling apart; south nest gone; new nest midway between two old nests with 1 Golden Eagle on rim and 1 about 10 feet away (1 Bald Eagle and 14 unidentified eagles in area).
12/2/1960: all nests gone (1 Bald Eagle and 2 Golden Eagles in area).

Meade Co.: 13 miles east of Meade.
January, 1959: nest first seen, in good condition (1 unidentified eagle near).
1/30/1960: nest in good condition (no eagles present).
12/4/1960: nest in fair condition.
11/26/1961: nest nearly gone.

Ford Co.: 3 miles northeast of Ford (in heron colony).
1/14/1959: one heron nest seemed enlarged (Bald Eagle in area).
12/17/1959: nest built on old heron nest, not complete.
12/5/1960: nest in good condittion (2 Bald Eagles in adjacent trees).
11/25/1961: nest in good condition (1 Bald Eagle near).
11/24/1962: nest falling apart.

Neosho Co.: Pool 3, Neosho County Waterfowl Management Area.
January, 1966: Bald Eagle nest built.

Wallace Co.: 3 miles east of Sharon Springs.
4/16/1966: eagle nest seen ½ mile east of heron colony.

From the data it seems that most nests were built in January. No explanation can be given at this time for building these nests and not attempting to rear young in them.

Department of Botany, The University of Kansas, Lawrence, Kansas, 7 May 1966.

A Note on the Plumage of the Harris Sparrow.—Swenk and Stevens (*Wilson Bull.*, 41, 1929:129–177) state that Harris Sparrow maintains its adult plumage after the completion of the second prenuptial molt. They mention slight seasonal changes involving the cheeks and postauricular spot which occur after the second prenuptial molt. Park (*Proc. Oklahoma Acad. Sci.*, 16, 1936:29–32) mentions a bird that had a solid black throat and chin on 3 May 1935, and on 9 December 1935, its chin was black and its throat was black with some white.

On 26 March 1966, I caught a bird (U. S. Fish and Wildlife band no. 59-128830) on the F. B. and Rena G. Ross Natural History Reservation, a study area of the Biology Department of Kansas State Teachers College of Emporia. This bird's chin and throat were about 50 per cent black and 50 per cent white. The bird had been

originally banded on the Ross Reservation as an immature on 14 February 1963. It returned to the Ross Reservation again on 21 April 1964, and on 22 April 1965. On this last date it was described as having its throat mostly white by Mr. Dale Greiner, who was banding Harris Sparrows at that time. This means that when I caught the bird it was at least in its fourth year and still did not have a typical adult plumage.

The data indicate that at least some Harris Sparrows do not have a typical adult plumage by their fourth year. However, the possibility exists that Harris Sparrows are somewhat polymorphic with respect to plumage, and the plumage described above, with a partially white chin and throat, could be normal adult plumage.

I thank Dr. David F. Parmelee and Mr. Dale Greiner for advising me in my study. I also thank the Biology Department at Kansas State Teachers College of Emporia for allowing me to conduct a study on the Ross Reservation. My study was supported by a Kansas Heart Foundation Grant.—WALTER D. GRAUL, *Kansas State Teachers College of Emporia, Emporia, Kansas, 6 October 1966.*

Pheasant Nest Parasitized by Bobwhite.—Parasitic egg laying is a well known habit of cowbirds (Icteridae) and several other bird species are known to lay eggs in nests of other species (cuckoos, honeyguides, weaver birds, and ducks).

An interesting case of such brood parasitism was observed near Ames, Cloud County, Kansas, in 1966, involving the Ring-necked Pheasant (*Phasianus colchicus*) and the Bobwhite (*Colinus virginianus*). On 3 May a female pheasant was flushed from a nest that contained 10 pheasant eggs and six Bobwhite eggs; another pheasant egg was found in a small cup-like depression in grass nearby. The nest was on a steep, grassy, west-facing slope in open woods. On my second visit to the area several days later, the nest had been abandoned. The nest and eggs were collected and are now in the Biology Department of Miltonvale Wesleyan College.

To my knowledge, there has been only one previous report of Bobwhite eggs in a pheasant nest. Blain (*Wilson Bull.*, 66, 1954:217) found a pheasant nest on the outskirts of Detroit, Wayne County, Michigan, that contained 13 pheasant eggs and eight Bobwhite eggs. This nest was also abandoned. Stoddard (*The Bobwhite Quail* (Chas. Scribner's Sons, New York) 1932:460–72) found that Bobwhites parasitized bantam chicken nests. Perhaps Bobwhites lay eggs in pheasant nests more commonly than the literature would suggest.—MERRIL G. MCHENRY, *Miltonvale Wesleyan College, Miltonvale, Kansas, 15 September 1966.*

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